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TRAINABILITY OF ABILITIES: A REVIEW OF NONSPECIFIC TRANSFER ISS--ETC(U)
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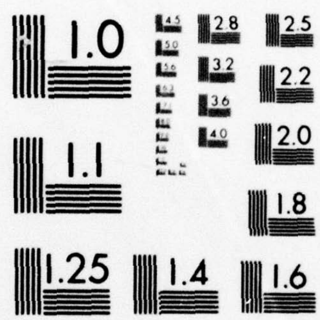
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Trainability of Abilities:

A Review of Nonspecific Transfer Issues Relevant to Ability Training

Joyce C. Hogan

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A REVIEW OF NONSPECIFIC TRANSFER ISSUES

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Abstract

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INTRODUCTION

The identification of human abilities accounting for individual differences in cognitive, perceptual, and motor aspects of human performance has received extensive contemporary research (cf. Fleishman, 1964, 1972; French, Eckstrom, and Price, 1963; and Guilford, 1967). Considerable investigative effort has resulted in the conceptualization of abilities as broad capacities underlying performance in complex skills and related to performance in a variety of human tasks (Fleishman, 1967a, 1972). Typically, abilities are identified through correlational studies of human task performance, in which the fact of individual differences is exploited to gain insights about common processes required to perform different groups of tasks. Thus, abilities are defined by empirically determined relations among observed separate performances. From this conceptualization, skills are more specific, and define levels of proficiency in particular tasks. These skills can be described in terms of component abilities required to perform them, with certain abilities shown to underly performance in many superfically different human tasks.

Fleishman and his associates have shown that abilities are related to progress individuals make in learning new, more complex skills, and to the final levels they attain after given amounts of training in these skills (Fleishman, 1967b, 1972; Fleishman and Hempel, 1954, 1956; and Fleishman and Fruchter, 1960). Similar investigations examined relations of abilities to learning rates and to a variety of learning measures (Fleishman and Ellison, 1969; Fruchter and Fleishman, 1967). From this research, it appears that abilities are more general than

specific skills. There is much information now available on the range of tasks requiring different abilities. Further, there is evidence that abilities relate to progress in learning and training.

A key question that remains unanswered, however, is whether training directed at improving abilities will result in transfer to several tasks and to more complex tasks in which common abilities are involved. If so, ability training may provide a more efficient approach for training individuals to perform a variety of different tasks than training for each specific task.

The idea that human abilities can be improved through training is a practical notion receiving little direct investigation. Although most abilities are the product of earlier learning and genetic factors (Ferguson, 1956; Gagne and Fleishman, 1959), they are defined as relatively stable attributes in the adult (Fleishman, 1972). Consequently, it may be unlikely that training results in improvements over the original capacity. This assumption has not been tested and it remains an empirical question whether certain intensive training experiences can improve general abilities. The issue is of sufficient importance to warrant consideration.

Of inherent importance to this issue is research on transfer of training. The purpose of the present paper is to examine earlier work on transfer of training relevant to ability training issues. The empirical question is whether training on tasks known to require a particular ability will result in positive transfer to new tasks requiring the same ability. This appears to be encompassed in the area Postman (1971) designates as nonspecific transfer.

Training for nonspecific transfer must include some degree of practice on tasks that are dissimilar to the transfer criterion task. As applied to training abilities, this requires (1) identification of tasks known to require a specific ability, (2) training of the selected tasks to some criterion level, and (3) transfer to a novel task(s) involving the same ability. Transfer is assessed by comparing changes in experimental and control groups who have not received training.

There are few direct tests of the hypothesis that training basic abilities may facilitate transfer between tasks requiring the same abilities. Consequently, a review of nonspecific transfer research, in a variety of settings, may be instructive. The present paper reviews previous research on nonspecific transfer in terms of the implications for ability training, in several areas felt appropriate to the problem. These include experimental, laboratory studies as well as research carried out in a number of applied settings (e.g., training simulator evaluation, educational intervention programs, and vocational skill development). The review is not meant to be exhaustive, but the studies reviewed are illustrative of the issues involved and their implications for ability training.

EARLY EXPERIMENTAL RESEARCH ON NONSPECIFIC TRANSFER

Early experimental studies of transfer have implications for questions about nonspecific transfer. The stimulus for this research in the early 1900's was the question of whether memory could be trained. The first recognized experiment in memory training was conducted by William James (1890, I, pp. 66f), who trained subjects in memorizing one author's poetry and then had them transfer to memorizing poetry of another author. Prolonged practice in memorizing poetry did not lead to increased efficiency in memorizing verses of another poet.

James' negative results and failure to introduce a training control provided by a pretest were followed by Ebert and Meumann's (cf. Sleight, 1911 pp. 389-395) study in memorization training. Their basic question was whether there is a general memory ability that can be trained using a wide range of verbal material involving memory. The experiment was conducted over a nine month period. Sets of criterion tests consisted of meaningful material, meaningless material, German words with Italian equivalents, verse, and prose extract. Results of the training were evaluated by comparative analysis of the pretests and a subsequent test administration. The criterion tests indicated a considerable and general improvement of memory ability. This was further confirmed by a third series of tests administered at the conclusion of training. Meumann and Ebert concluded that memory functions could be improved by training with any material involving the use of memory and that memory increments were proportionate to the relationship between training and test material.

Since the criterion tests were not equated across administrations, and no allowances were made for the training effects of the three test administrations, the results cannot be taken too seriously. Dearborn (1909) demonstrated subsequently that the same results could be obtained by administration of the criterion tests alone.

Winch (1910) investigated prose memory ability as a function of rote memory training. He matched groups according to prose pretest scores, trained one group in rote memory tasks, trained a control group in drawing geometric designs, and posttested all subjects on a test "similar" to the preliminary tests. The result indicated superiority of the rote memory practice group over the control group. Sleight (1911, pp. 399-400), critical of this investigation for its inequality of pre- and posttests, conducted a methodologically sound investigation in nonspecific training of memory ability. Three experimental groups and a control group were matched on the basis of ten different pretests. The experimental groups were trained in memorizing either poetry, prose, or numerical tables. The control group performed arithmetic operations. Two series of counterbalanced posttests were administered to all groups. These were ten tests spanning a range of memory tasks. Although gains were shown by all groups over the pretest-posttest conditions, there were no significant between-group differences. Sleight concluded that there was no general memory improvement as a result of training nor was there any evidence for a general memory function. Instead, he posited that transfer is predicated on, and facilitated by, the existence

of common elements in training and test performance. These results and conclusions are supported by early experiments in training perceptual abilities (Thorndike and Woodworth, 1901) as well as the more extensive memory training studies (Woodrow, 1927).

Postman's (1971) summary review of early experimental verbal and memory ability training extends the above discussion citing further investigations and providing extensive experimental detail. In reviewing this literature, both McGoech (1946) and Postman (1971) concluded that results of these early studies indicate transfer between tasks is greatest when conditions of transfer involve tasks of the "same class."

Studies of memory training led inevitably to questions of training learning. This was not stimulated by the success achieved in training memory abilities, but by the inquiries surrounding the idea of a general intelligence factor (Spearman, 1904, 1927). Hall's (1936) review of nine major investigations of a general learning ability and the degree to which this ability facilitates performance concluded that if a general learning ability existed, it was of little importance in determining learning performance across situations. Unsatisfied with the validity of this conclusion, Hall identified irrelevant factors that possibly contaminated earlier studies and conducted his own investigation. Hall concluded that the relationship between learning tasks was slight, and that the review data as well as his own results indicated a high degree of specificity in learning and task performance.

Hall's review and investigation coupled with similar findings (e.g., Husband, 1941; Woodrow, 1939) as well as the psychometric evidence against a "g" factor (Thurstone, 1938) contributed to reduced research interest in nonspecific transfer. The issue seemed resolved. The methodological implication was for research in measuring specific transfer effects. Although slow to evolve, the transfer issue was pursued largely through experimental examinations where the highest degree of "stimulus similarity" was present during training and transfer. Theories based on the prediction that facilitation requires "identical elements" in training and transfer, (cf., Gibson, 1940; Osgood, 1949; Robinson, 1927; Thorndike, 1903) stimulated a wave of investigations. This general research interest has continued through revision of theoretical predictions, evaluation of specific theoretical transfer models, and empirical tests of both. However, there is relatively little contemporary interest in either theoretical or empirical analyses of nonspecific transfer, and virtually no contemporary direct tests of the hypothesis that abilities can be improved through the use of diversified training.

Two relevant areas which have received considerable attention are studies of "warm-up" and "learning to learn" phenomena. The paradigm used in these areas is not unlike that used to study transfer of training. These two research areas contribute indirectly to the analysis of nonspecific transfer effects and are discussed in the next sections.

WARM-UP: A SPECIAL CATEGORY OF NONSPECIFIC TRANSFER

Warm-up is an activity that establishes a preparatory set allowing the performer to respond in a task with few decrements. The warm-up literature is relevant paradigmatically to nonspecific transfer since warm-up practice occurs just prior to criterion task performance and consists of practice on tasks which are different from the criterion task.

The basic premise that warm-up is a source of positive effects in a transfer task gained early acceptance in both verbal learning (Heron, 1928) and motor learning (Bell, 1942; Snoddy, 1935). The idea that warm-up is a process independent of strengthening necessary habits is a basic assumption (Thorndike, 1914, pp. 67-68.). The theoretical explanation for the warm-up phenomenon is that activity or training induces appropriate postural and sensory adjustments required for performance on the transfer task (Ammons, 1947a; Irion, 1948). Ammons (1947a) contends that these postural adjustments form a set that dissipates over rest intervals. It is loss of set, therefore, that can account for performance decrements when training is resumed after a rest interval. The beneficial effects of set, induced by warm-up or training, appear to be an increasing function of amount of set-appropriate training (McGeoch & Irion, 1952, p. 334) and related inversely to intertask interval length (Adams, 1952, Ammons, 1947a, 1947b, Carron, 1967).

There are two implications of warm-up as a component of nonspecific transfer. First, warm-up effects are dependent on temporal

manipulations. Activity set is maintained as long as the performer is training. When rest intervals occur, performance decrements on the subsequent task are a linear function of elapsed time. Consequently, nonspecific transfer is facilitated by temporal reductions in intertask intervals. Second, to qualify as nonspecific transfer, the task must be neutral as distinguished from tasks that contribute to goal responses required by the transfer task. The strategy used to eliminate decrement over rest intervals is to require subjects to perform neutral tasks that provide proper postural and attentional adjustments but do not result in response strength increments.

Numerous research investigations of the effects of warm-up on criterion task performance use this approach. The review of the literature on verbal recall behavior by Adams (1961) can be summarized with three general points. In terms of the "set hypothesis" for warm-up decrement, brief warm-up activity just prior to recall facilitates verbal recall. Second, performance level on recall of verbal material is a positive function of amount of set-reinstating activity. Third, it appears that the temporal occurrence of warm-up is critical to positive effects. Generalizations from motor behavior are more difficult to draw, due in part to problems in developing "neutral" tasks (cf. Adams, 1961, p. 265). Ammons (1951) found no significant effects on performance using any set-reinforcing activities. Hamilton and Mola (1953) found that manipulating temporal placement of the warm-up activity resulted in no group performance differences. However, Adams (1955) showed that watching a partner perform a motor task resulted in less warm-up decrement when that

subject performed the criterion task than when subjects only rested prior to performance. Similarly, Barch (1963) demonstrated that left hand training on a motor task resulted in less warm-up decrement when transferring immediately to right hand performance than a group waiting 24 hours between training and transfer.

More recent theoretical ideas and empirical investigations in motor behavior clarify the role of warm-up in nonspecific transfer. Modifying the set hypothesis somewhat, Nacson and Schmidt (1971) contend that warm-up decrement is loss over a rest of a generalized preparation to respond. This generalized preparation involves support systems underlying performance such as activation, attention, and expectancy. In a series of experiments where the activity set was induced in one case by force estimation, and in another by limb positioning, and where these interpolated tasks did not contribute to criterion habit strength, warm-up decrement on the criterion task was nearly eliminated. Further, this reduction in warm-up decrement was due to the nature of the interpolated task and not the motivational effects of knowledge of results. The activity-set hypothesis not only accounted for these findings but also for earlier results from Irion (1949), Irion and Wham (1951), Adams (1955), and Rosenquist (1965). The interpolated activity reinstated a portion of the activity set--attentional adjustments, activation, expectancy, etc.--necessary for proficient criterion task performance. The idea that nonspecific warm-up transfer was facilitated by a set consisting of eye movements or postural adjustments was not consistent with these findings.

LEARNING TO LEARN: A SPECIAL CATEGORY OF NONSPECIFIC TRANSFER

In the foregoing discussion of warm-up as a category of nonspecific transfer, warm-up activity or interpolated task performance was viewed as a training analog and its effects on the criterion task were evaluated. It appears that there is some overall benefit of nonspecific warm-up "training" on reducing criterion task performance decrements. The critical variable in eliciting nonspecific warm-up effects is the temporal relationship between warm-up and criterion task performance. Consequently, those transfer effects that dissipate most rapidly are characteristic of the warm-up phenomenon; however, those effects that are more enduring represent another category of nonspecific transfer--learning to learn. This distinction has received some validation (cf., Hamilton, 1950; Heron, 1928; Hunter, 1955). The implications of Thune's (1950) investigations are fundamental to the classic distinction between warm-up and learning to learn.

Two studies conducted by Thune (1950) investigate the effects of varying amounts and types of verbal activity upon the subsequent acquisition of paired-associate material. In the first experiment, groups were given equal training on two different paired-associates lists. Groups differed in the distribution of the training with the final training session consisting of either 0, 4, 6, 8, or 10 practice trials 10 minutes prior to transfer to an unrelated paired-associates criterion list. All groups transfered positively to the criterion task; the rate at which the new list was acquired was a direct function of the number of practice trials completed

in the final training session. In the second experiment, the methodology was essentially the same except the activity in the final training session consisted of either 10 trials of a non-learning color guessing task or 10 trials on a paired-associates list. Transfer to a different paired-associates criterion task indicated no differences between the groups; both kinds of preliminary training produced equal amounts of improvement in the criterion list. Thune concluded that the source of facilitation was the training of an appropriate, but nonspecific, set and not the nature of the training materials.

In reviewing the results of Thune's second experiment, Schwenn and Postman (1967) observed that the equality of the learning and non-learning practice effects may have been confounded by the fact that all subjects received some practice with paired-associates learning. Therefore, Thune's findings did not provide clear information about training non-learning tasks for transfer to a learning activity. Schwenn and Postman compared the differential effectiveness of a learning and a non-learning activity on transfer to a common list of paired adjectives. The training conditions for four groups represented the factorial combination of two types of tasks (learning and non-learning) and two amounts of practice. All groups, regardless of training, were more accurate on the initial transfer trials than an untrained control group indicating a general facilitating effect of verbal activity on criterion list learning. At both levels of practice there were substantially greater gains on the criterion learning by the groups practicing the verbal learning task as opposed to the groups practicing the non-learning task. Although

the results were interpreted in terms of warm-up and learning to learn, they also provide support to the nonspecific transfer phenomenon in the learning condition.

Experiments concerned with learning to learn (that is, acquiring learning skills through practice) can be viewed as a subset of non-specific transfer. The concept of learning to learn implies the development of strategies that facilitate performance in new tasks. This is possibly the result of experience or practice with diverse problems within a specific class. Harlow's (1949) pioneering work in this area accounts for the learning to learn phenomenon as the result of the formation of "learning sets." Establishing learning sets is a specific type of transfer training, where transfer is from practice on many different problems within a single class. Training or practice on a series of nonidentical learning tasks leads to improvement in the ability to perform on other tasks of the same class. This was demonstrated in a classic study by Harlow (1949) who trained monkeys on a series of different discrimination problems. Great intertask improvement occurred over the series of problems with performance on later problems becoming nearly error free. This general finding has received support across populations and learning tasks (see reviews by Harlow, 1959; Kimble, 1961; Postman, 1971).

Learning to learn requires preliminary practice on tasks that will transfer positively to performance on a dissimilar criterion task. Although there is evidence in support of this in verbal learning, few studies involving human motor discriminations are

available. Duncan's (1960) investigation using a movement task analog of a paired-associates task is an example. The task required pairing visual stimuli to movement responses of a hand-held lever. Ten tasks, each containing 13 different S-R pairs, were practiced one per day for 20 trials over two five-day weeks. Randomization of S-R pairs and the tasks themselves controlled for specific stimulus--or response--generalization and stimulus predifferentiation. Three results are important here. First, performance on each task was numerically higher than on the preceeding task, even though there was only a general similarity among each of the tasks. Second, most of the total gain of 65 percent improvement occurred over the first six tasks suggesting that almost the total variance in overall gain could be accounted for by practice on only half of the series of training tasks. Finally, over the 72 hour retention interval between the fifth and sixth task (all others were 24 hours), there was no evidence of either forgetting or reminiscence, suggesting full development of the ability required in performing these similar tasks.

The learning to learn situation raises the question of what is responsible for changes in performance when the effects of positive transfer cannot be attributed to the pairing of specific stimuli and responses. Postman (1971) suggests that the explanation of a strengthened ability is not entirely adequate. He contends that an explanatory analysis of the nonspecific transfer phenomenon should reflect on task characteristics and conditions of practice that interact with the performer's habits and skills. Fredericksen

(1969) advances the explanation of transfer one step further. He suggests that consideration must include not only an analysis of the the individual's abilities and the characteristics and requirements of the task, but also the "strategies" used by the learner. These strategies are the mediators of transfer.

ISSUES IN POSITIVE NONSPECIFIC TRANSFER

A number of issues impinge on the degree of transfer achieved between conditions of training and criterion task performance. This section discusses such well defined issues as task characteristics, conditions of practice, and strategies underlying the transfer phenomenon.

Task Characteristics and Conditions of Practice in Nonspecific Transfer

Several investigations attempt to reflect on requirements for nonspecific transfer by manipulating task characteristics and conditions of practice. Postman and Schwartz (1964) analyzed transfer specificity by manipulating similarity between training and criterion test characteristics as a function of practice method (serial or paired-associate list learning) and material. The authors hypothesized that if responses and habits responsible for performance increments were specific to conditions of practice, then variations in the learning task should be reflected in transfer. Method of practice in two groups remained the same as the test task, and for two groups the training and test method was dissimilar. Similarly, the materials remained the same for two groups and for two groups it changed.

Two results of this experiment have implications for nonspecific transfer. First, substantial improvement in performance on the criterion test list occurred for all conditions of pretraining. The authors concluded that the transfer was independent of the specific method of practice or class of materials used in training. Second, in the analysis of performance on both criterion tasks,

transfer effects were specific to the method of practice but not to the materials used in training. This appeared to be the case only in the terminal stages of acquisition of the test list. Similarity of training and transfer had virtually no performance advantage early in acquisition of the transfer test.

An early investigation of the influence of the amount of practice and training-transfer similarity on nonspecific transfer was conducted by Duncan (1953). The basic task required subjects to match the appearance of a light stimulus with a lever movement to one of six radially arranged positions. Four levels of practice and three degrees of similarity between training and transfer were studied. All groups transferred to a criterion task which consisted of 60 trials of pairing stimuli and movement responses that were of differing degrees of similarity to their training trials. The overall result was that positive transfer was obtained by every experimental group. Task learning during the training period, regardless of practice amount or similarity between training and transfer, facilitated performance on the criterion task. Differences in experimental groups did exist, however, and acquisition of the criterion task was directly related to amount of practice and degree of training-transfer similarity.

What accounts for transfer, which in this case is nonspecific transfer, when the differential effects of practice are held constant? Duncan (1958) studied the degree to which positive nonspecific transfer was due to experience with a variety of tasks as opposed to practice per se--i.e., he asked whether anything is

learned from practice on a series of tasks that is not learned from an equal amount of practice on only one task. Results of this study indicated that all degrees of varied training produced better transfer than constant training, and more varied training produced more positive transfer than less varied training. The most important aspect of varied training was variation itself--not the amount of practice per variation.

Russell (1974) further clarified the effects of practice on different tasks of the same type on transfer to a novel criterion task. Three experimental groups and one control group each received sixty practice trials moving a pencil to a target from various starting positions. The experimental groups were assigned practice at either six different starting positions, one non-criterion starting position, or the criterion starting position. After the practice trials, all groups completed thirty trials on the criterion task using the same target but a starting location different from any of the practice trials. Results indicated that the group practicing six different starting locations and the group practicing the criterion movement had the smallest error on the criterion transfer task.

The results of this series of studies suggests that non-specific transfer is a phenomenon that can be demonstrated in both verbal and motor skills. Research evidence on the beneficial effect of training variability exists elsewhere in the specific areas of problem solving (Morrisett & Hovland, 1959) and pattern recognition (Attneave, 1957; Dukes & Bevan, 1967). The inferred

existence of nonspecific transfer supports the assumption that some underlying ability required in similar task performance is strengthened. Although amount of practice is related directly to nonspecific transfer acquisition, it does not account for all of the variance in positive nonspecific transfer. Conditions of training that involve variations in tasks of the same type, facilitate positive transfer to novel tasks. Since practice on a variety of tasks results in positive transfer to a novel task, it would appear that abilities required for performing tasks of the same class were trained.

Strategies for Nonspecific Transfer

A plausable explanation for the occurrence of nonspecific transfer is the use of cognitive strategies to make the transition from training to criterion task learning. The use of cognitive strategies to mediate nonspecific transfer is not a new idea. Bartlett (1932), in a discussion of perception and memory, hypothesized that through past experience with a wide range of stimuli, an individual can abstract and use redundant aspects of the environment to form concepts or prototypes. The concept forms the basis of a rule and rules provide the substance of strategies. The major prediction from this theoretical notion is that without receiving previous experience with a given specific set of task stimuli, one can transfer positively to that task after training on a wide variety of tasks where some redundancies occur.

Although these ideas are not recent, there are few attempts to operationalize the theoretical concepts allowing empirical investigation. Several investigations in pattern recognition reflect on the mediating role of strategy in the nonspecific transfer paradigm.

In an investigation of transfer without a prototype, Edmonds and Evans (1966) found that training with patterns having common characteristics better facilitates transfer to a second memory reproduction task than training with random visual patterns. The two important findings in this investigation are (1) nonspecific transfer occurred without knowledge of results and (2) the strategy involved in abstracting pattern commonalities was vital in promoting transfer to a different task. Positive transfer did not result with random pattern training where no redundancy or pattern commonalities occurred. Positive transfer was contingent on developing a strategy for dealing with a range of visual patterns.

This work was extended by Edmonds, Evans, & Mueller (1966) to determine whether training on visual patterns without a specified prototype facilitated transfer in reproducing a prototype pattern never seen. Results indicated that this training enhanced transfer and also replicated the Edmonds and Evans (1966) findings. This suggests that nonspecific training where the general strategy involved delineating concepts or prototypes not only facilitated transfer to a different task whose performance was predicated on the same general strategy, but established a basis for learning to learn. The results of these two studies have been replicated and the paradigm has been extended in several other investigations (Edmonds & Mueller, 1966; Edmonds, Mueller, & Evans, 1966; Evans 1967a, 1967b; Evans and Edmonds, 1966).

Given that subjects develop, through training, a strategy for reproducing sets of patterns which are distortions of a

prototype, Posner and Keele (1968) conducted a series of experiments focusing on degree of variation in training and the nature of the strategy information abstracted. In one experiment, two groups of subjects were trained in classifying visual distortions of four different prototypes, while a control group received no experience with the materials. The training stimuli consisted of a series of random dot patterns. The visual displays were distortions of three prototype patterns and one random pattern. After training subjects transferred to a criterion task of classifying more complex variations of the basic prototypes. The results indicated that subjects trained on the more abstract distortions of the prototypes produced more accurate classifications in the transfer task distortions than the other groups. These data were confirmed by a second experiment.

A third experiment attempted to evaluate the differential degree of abstraction from both the visual distortions as well as the actual prototype. There were no differences in subjects' abilities to classify accurately the original prototypes and the training distortions, however, these classifications were significantly more accurate than classifications of novel or random patterns.

Taken together, these studies suggest that when training is varied and not identical to the criterion task, positive transfer is possible if the performer perceives commonalities among the training tasks. Positive transfer is also predicated on the usefulness of training commonalities in effectively solving the

transfer task. In this area of research, it appears that nonspecific transfer was facilitated, to some degree, through the performer's adaptation of a strategy derived from abstracted stimulus commonalities available in training.

IMPLICATIONS FOR ABILITY TRAINING FROM APPLIED RESEARCH

A number of applied areas of research have implications for nonspecific transfer. The first concerns the widely investigated area evaluating the effectiveness of training devices. These investigations focus typically on questions of "simulator fidelity" of the device and the effects on transfer to the criterion task. Degree of fidelity in assessing training device effectiveness has been addressed across the range of the fidelity spectrum; however, for purposes of the present paper, attention is placed on "low" fidelity studies with minimal similarities between training and transfer task performance. Low fidelity training and transfer is analogous to nonspecific transfer.

The traditional position of many researchers in this area is that positive transfer increases as a function of stimulus similarity between the initial training task and the final or criterion task (Gagne, 1954, 1962). Ellis (1969, p. 402) extends this basic tenet across a wide range of learning tasks and contends that if the stimuli are varied in training and transfer, but the response remains identical, positive transfer is a function of stimulus similarity.

There are, however, a number of contradictory findings that leave the hypothesized requirement of high fidelity for maximum positive transfer open to question. It appears that conditions of high fidelity do not always produce the greatest degrees of transfer. Voss (1969) found that simulator pilot training using

a physically similar device produced no better transfer that training in reduced conditions. Also, Valverde (1973, p. 518) reviewed a series of flight simulator studies where mock-ups were as effective in training as high fidelity simulators. The idea that benefits can be derived from training devices lacking in physical fidelity, but sufficient in task fidelity, has some empirical support (cf. Wheaton, Rose, Fingerman, Korotkin, & Holding, 1974, p. 67). Finally, it appears that training on simulators of low fidelity produces more positive transfer than training with instructional classroom materials (Valverde, 1973; Wheaton et al., 1974, pp. 65-67).

This literature provides some support for the idea that abilities required in operating machines can be trained without requiring identical training and transfer tasks. The degree of nonspecificity in simulator training that results in positive transfer remains an empirical question addressed in recent reviews by Valverde (1973) and Wheaton et al. (1974).

A second applied area of research having implications for ability training is educational research. There has been a historic educational interest in training originality, creativity, and cognitive abilities both in the laboratory and in applied settings. The following paragraphs briefly review the principal findings emerging from this work.

The most programmatic work in originality training was conducted by Maltzman (1960) and his associates (cf. Maltzman & Morrisett, 1952; Maltzman, Brooks, Bogartz, and Summers, 1958;

Maltzman, Bogartz, & Breger, 1958). In a series of well controlled training studies, Maltzman, Simon, Raskin, and Licht (1960) investigated variations in procedures responsible for facilitation of original responses. Originality was assessed as a direct function of the number of unique responses and an inverse function of response repetition. Results indicated that the standard training procedure of training subjects to evoke different responses to the same stimulus word produced significantly greater facilitation of originality. Other results indicate that the effects of originality training may persist for as long as two days. The authors concluded that nonspecific training of originality resulted in learned behavior.

The area of creativity has been reviewed extensively by Torrance (1972). A longitudinal program that attempted to train creativity in adults was conducted by Parnes and Noller (1972). An experimental group and a matched control group volunteered for participation in the two year program. The experimental group received four semesters of training in creative problem solving, general semantic processes, and awareness development. The control group received no courses in the creative studies area. The authors drew several interesting conclusions from the results. First, the nonspecific training provided by a creative studies program enhanced performance on tests of creativity. Second, training augmented the ability to not only produce ideas, but to evaluate them. Finally, this training facilitated productivity in non-academic achievement areas requiring creative performance.

A nationally recognized effort, focusing on training cognitive abilities for transfer to academic skills, involved early intervention preschool programs. This work, sponsored by HEW under the Head Start Program, was reviewed in detail by Bronfenbrenner (1974). The actual training in these projects varied considerably. Some programs report training in verbal and conceptual activities while others emphasized perceptual and motor training. The training sequence reported ranged from conventionally structured to open space and free play. Length and quality of training were difficult to evaluate and control. Consequently, very little can be generalized or concluded about specific effects of this training on general ability development. The major limitation in evaluating relevant educational research is lack of adequate experimental controls. Without both inter- and intra-group control comparisons across investigations are difficult. Consequently, it is difficult to say if positive transfer results are a function of training, development, placebo effects, or environmental factors.

Another applied area relevant to the present review is that of occupational psychology. In particular there is interest in the characteristics of jobs that are considered common (e.g., Fine & Wiley, 1971; Fleishman, 1975; Holland, 1973; McCormick, 1976; McKinley, 1976). In so far as there are attempts to group and classify occupations in terms of common elements, skills, or abilities, this information should have relevance to transfer of training issues. Although considerable progress has been made in developing conceptual systems and methodologies of identifying these groupings, there is little direct evidence on their

relation to transfer of training across tasks comprised of common abilities (McKinley, 1976; Sjogren, 1977). However, the assumption is that individuals with high levels of proficiency in nonspecific, general skills (i.e., problem solving, decision making, creativity) are more likely to show transfer across tasks involving these general capacities (Sjogren, 1977).

Although the demonstration still needs to be made, research on job dimensions has reached the stage where such tests may now be possible and will have implications for the trainability of abilities. Altman (1976) discusses some of the issues in reference to the acquisition of occupationally oriented skills which may optimize transfer across tasks and for defining task similarity in ways which will facilitate transfer from school to job performance. However, it is not known from this literature if general ability training is feasible or if it will facilitate transfer across tasks.

SUMMARY AND CONCLUSIONS

The degree to which basic human abilities are trainable is a question posed nearly 90 years ago that remains relatively unanswered. The idea that abilities might be trained to transfer positively to different tasks requiring those abilities received some early attention by investigators interested in memory training. Several of these studies succeeded in training memory abilities when training consisted of a wide variety of verbal materials. However, later efforts with more sophisticated methodology did not support these findings and interest in nonspecific transfer research waned.

There appears to be little contemporary interest in nonspecific transfer, per se. However, a few lines of research employ a similar paradigm and thus allow inferences to be drawn. Nonspecific transfer is supported indirectly by research on warm-up and learning to learn phenomena. Although the training tasks employed have only minimal similarity with the criterion task, transfer gains across these tasks have been shown.

There are three important considerations in analyzing nonspecific transfer and support for the idea is generated through each. First, task characteristics tend to be more predictive of transfer than just the training materials themselves. Second, it appears that variability of training or practice within a class of response types facilitates positive transfer. Finally, there is some evidence to suggest that transfer may, in part, be mediated by the adoption of a strategy requiring abstraction of important features in training which are required in transfer performance.

Some additional support for the nonspecific transfer notion comes from areas of applied research. First, in the area of simulator training conditions, it appears that very generalized training simulators promote transfer to a specialized task. The second area, educational research, has attempted to use a variety of training materials to develop intellectual and cognitive abilities. The programs report some modest success. Also, there are encouraging implications to be drawn from recent work on vocational skills.

This review suggests that there is some indirect evidence to support the notion that abilities can be trained. What it also suggests is that there is a need for a direct empirical test. Predictions of whether abilities can be improved through the use of diversified training are hampered by at least two powerful limitations. First, there are no direct assessments of the question. The early research in memory and learning perhaps reflects most clearly and positively on the issue; however, little support is generated by more recent evidence. The second limitation is that the data are most convincing in the area of specific transfer. These two transfer models are theoretically incompatible and resolution of this incompatability will require either theoretical revisions or direct evidence reflecting non-specific transfer.

A point to which the discussion must return concerns the implications for the traditional concept of ability, if in fact, an ability can be trained. Given that abilities are conceptualized as "fairly enduring traits, which in the adult are relatively difficult to change" (Fleishman, 1967, p. 166), by definition

they should not be susceptible to enhancement by training. If it can be demonstrated that abilities can be trained through a variety of tasks requiring that ability and transfer to other tasks where the same ability is involved, then the ability concept will require revision. One of many plausible explanations of the positive transfer effects from nonspecific training is that some ancillary "support" systems (i.e., memory, recall, anticipation, movement time, etc.) may facilitate ability functions. As an illustrative example, it might be that through nonspecific training, the recognition process of deciding when to use an ability is strengthened. The overall result is positive nonspecific transfer but not due to ability training in the strict sense. Although this hypothetical explanation requires empirical investigation, support for this idea would leave the traditional ability concept intact and suggest that training should focus on processes surrounding the ability.

Applied implications for ability training and nonspecific transfer are numerous. If ability training is feasible, one could raise ability levels of those individuals whose education or jobs require specific abilities that may be deficient. A second implication of ability training has importance for organizational concerns. If abilities are trainable, such training will increase the flexibility of personnel assignment in jobs. Personnel would have a broader range of capabilities for performing within a wide range of tasks. The utility of the individual is enhanced to the extent that he can assume a greater variety and number of

tasks. Finally, since ability training extends across tasks requiring the same ability, the overall result is that specific task training requirements might be substantially reduced.

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